Composite Earth Structure

January 23rd , 2012

History:

Working on the Howard Hansen Dam, Interim Fix 2009, gave Farid A. Chouery and Robert (Rob) E. Romocki the inspiration for this idea to solve the seepage problem. Howard Hansen Dam is an eastern embankment dam on the Green River, 21 miles (34 km) east of Auburn, Washington. Farid suggested three rows of Micropiles with an outside infill grout for the fix; Rob suggested two rows of Micropiles with an infill grout between the Micropiles. Farid realized the composite action and pursued the technical issues not just for seepage but also for strength. The interim team presented the design using this idea to Colonel Anthony O. Wright; it was not selected in 2009. The idea was pursued on the Elliot Bay Seawall when Farid for strength ran into technical difficulties; specifically, the shear specified by the Army Corps of Engineers versus the ACI (American Concrete Institute) and downgraded by the city consultants claiming concrete has little tension. Finally, Farid changed the configuration with the help of Professor John F. Stanton in the Structural Department of the University of Washington, where the two rows of piles were altered into a pyramid shape. Thus, the idea was accepted and selected as an alternative to the Elliott Bay Seawall. It remains the original inventor, Farid A. Chouery, for strength. The idea was never pursued for hill stabilization.

An example follows the Invention and its applications:

Description: **Install two vertical rows of piles, such as micropiles, in a line or a curve; it can be any piles that can hold tension when the load can be in both directions or as needed to achieve composite action with infill grout, lean concrete, rocks or soil. The piles act as rebars. A single row of piles is sufficient if the load is in one direction. The piles can be angles in any direction to use tension or compression of the piles. The Invention is not limited to earth loads but includes hydrostatic or seepage problems. In stabilization, the piles can also be pre-stressed to increase friction on the slip surface.**

Application Summary: **Dams stabilization problems, slope stability problems, foundation settlement problems, shoring walls, and walls.**

Example:

A hill has a 60pcf pressure from slope stability calculations on a required wall to be inside the hill. The depth of the wall at the required stability location is 20 ft. The Micropiles are 12-inch diameter, 3 ft on center, and the arching action is the full span of 3 ft with 4000 psi concrete. The passive is 300 pcf, with a full span of 3 ft front and back. The infill grout is 7 ft wide of estimated 1000 psi concrete with 75 psi adhesion bond, and the friction angle of the infill grout is not to be considered. The calculated maximum moment is 2356.2 ft-kip on 3 ft at 11.18 ft below the wall, the embedment at 1.0 Safety Factor is 30.00, the required embedment is 35.00 ft to achieve an overturning safety factor of 2.42 and a sliding safety factor of 1.58. The maximum shear is 135 kips over 3 ft at 5 ft below the wall. The steel has 60 ksi. The required area of steel is 12.8 in^{2}; use 3 # 18 in the Micropile using a spreadsheet. The tension in the steel = 12.8x60ksi = 768 kips. Adhesion = 75 x π x 1'x144 x (35-11.18)/1000 = 808 > 768. The shear per the Army Corps is 10x78x36√1000 = 888 kips per the ACI = 0.85x4x78x36√1000 = 302 kips; both are greater than 135 kips calculated shear.

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